Effect of N-volatilization from urea on rice and jute emergence and seedling growth in some soils of Bangladesh

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Negative correlation was observed between the volatilization losses of N from added urea in the presence of decomposable organic materials and the germination of crop seeds in some soils of Bangladesh

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The volatilization losses of N from urea added to soils have been considered to be related to the presence of lime and high pH (Volk, 1959; Wahhab *et al.*, 1959; Khan and Hoque, 1965); high soil temperature (Ernst and Massey, 1960; Harding *et al.*, 1963; Gasser, 1964); low exchange capacity (Volk, *ibid.*); Anderson, 1962; Harding *et al.*, *ibid.*); loss of moisture from soil (Martin and Chapman, 1951; Volk, *ibid.*; Ernst and Massey, *ibid.*; Harding *et al.*, *ibid.*); or high moisture status leading to water-logging (Sreenivasan and Subrahmanyan, 1935; Wahhab *et al.*, *ibid.*; Okuda *et al.*, 1960). However, little information is available on the volatilization losses of N from urea in the presence of added decomposable organic materials in soils. Meyer *et al.* (1961) and Anderson (1962) observed greater losses from volatilization when urea was applied to soil covered with plant debris. Khan and Rashid (1971) and Rashid (1977) observed increased gaseous N-losses from added urea in presence of decomposable organic materials having high C/N ratios.

It has also been reported that the free ammonia produced from the hydrolysis of urea damaged germination and growth of crops (Brage *et al.*, 1960; Low and Piper, 1961; Widdowson *et al.*, 1964).

In sub-tropical and tropical humid regions, the addition of organic materials in the form of farmyard manure, composts, *etc.* followed by the application of fertilizer-N creates a condition where chemical transformation of N-carriers such as urea are likely to occur, leading to gaseous losses of N from the presence of decomposable organic materials. Research has been undertaken to correlate the gaseous N-losses from added urea, in the presence of decomposable organic materials, with germination and seedling growth of rice and jute in four sub-tropical soils of Bangladesh.

Materials and methods

Soils

Four soils, the Brahmaputra alluvium, the Gangetic alluvium, the Coastal saline and the Madhupur red soils were collected from a depth of 0–25 cm, dried in the air, ground and passed through a 10-mesh sieve. The mechanical composition and chemical characteristics of the soils are presented in Table 1.

Organic materials

Cow-dung, molasses, composted water-hyacinth (*Eichhornia crassipes* (Mart.) Solms) and bonemeal were used as sources of organic matter. Cow-dung and water-hyacinth plants were allowed to undergo decomposition for a period of two months in an incubator at 28°C in the laboratory, with occasional stirring; the decomposed materials were then oven-dried at 70°C. The cow-dung contained 1.18% N and 33.4% organic C, giving a C/N ratio of 28. The water-hyacinth compost contained 1.05%N and 20.8% organic C, with a C/N ratio of 20. The molasses contained 48.3% organic C and a trace of nitrogen; the bonemeal 2.11% N, 7.80% organic C and 9.05% P, with a C/N ratio of 3.7. The analytical data are reported on an oven-dried basis. The cow-dung, water-hyacinth compost and bonemeal were added to soils in the oven-dried form, and the molasses was applied air-dried. Cow-dung, molasses and water-hyacinth compost were applied at 227 kg organic C ha^{-1} and bonemeal at 27.2 kg P ha^{-1}.

Procedure

Two series of experiments were laid out in a room, fitted with wide glass windows, with each soil: (1) to observe the volatilization losses of N from added urea; (2) to examine the effect of escaping gases on the germination and seedling growth of rice and jute up to seven days after sowing. Portions of air dry soils (200 g) were placed in petri dishes having an internal diameter of 14 cm and organic materials were uniformly incorporated with the surface soil. Moisture was maintained at 40% and the mixtures allowed to undergo reactions for seven days. The moisture level was thereafter maintained at 35%, adjusted every 24 hours. At the end of ten days, urea (C.P. grade) was applied at the equivalent of 54.4 kg N ha^{-1}, and uniformly incorporated with the surface soil in petri dishes; in the series of

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Table 1 Mechanical composition and chemical characteristics of the soils (0–25 cm depth)

Analysis	Soils			
	Brahmaputra alluvium	Gangetic alluvium	Coastal saline	Madhupur red
Mechanical (air-dry basis)				
Sand (%)	39.0	38.5	57.3	49.3
Silt (%)	41.5	40.4	26.8	21.5
Clay (%)	18.5	21.1	15.6	29.1
Moisture (105°C) (%)	1.0	1.2	0.9	1.3
Chemical (oven-dry basis)				
pH	6.8	7.5	8.2	5.5
Organic C (%)	0.82	0.60	0.54	0.51
NH_4-N (mg %)	1.80	1.05	0.52	1.50
NO_3-N (mg %)	2.42	1.42	1.30	0.56
Total N (%)	0.08	0.05	0.04	0.05
C/N ratio	10.3	12.0	13.5	10.2
Truog's P (mg %)	2.38	2.11	1.72	2.51
1% Citric acid soluble K (mg %)	5.19	4.25	3.61	5.98
Total P (%)	0.04	0.03	0.03	0.04
Total K (%)	0.62	0.05	0.41	0.50
Total Ca (%)	1.27	3.91	1.59	0.50

germination studies before the addition of urea, 50 seeds of rice of 'Latishail' variety (transplanted) and jute seeds of 0–2 variety (*Corchorus olitorius* L.) were sown per petri dish. Moisture status in all the treatments where seeds were sown was maintained at 35% up to day 12. From day 13 to the end of the observation period daily water additions were made taking averages of the amounts of water required to be added on days 10, 11 and 12. This average water addition was done because the actual loss of moisture could not be recorded because of the growth of seedlings and their transpiration. There were six different treatments in each soil, two replicates per treatment, as follows:

1, Soil (control); 2, Soil + Urea; 3, Soil + Urea + Cow-dung; 4, Soil + Urea + Water-hyacinth compost; 5, Soil + Urea + Molasses; 6, Soil + Urea + Bonemeal.

Urea-N loss experiment was carried out in one soil at a time and the germination study in all four soils but with one crop at a time (jute was sown in June and rice in August). Samples were withdrawn at three and seven days after the application of urea for the determination of total N and moisture. Germination of rice and jute seeds was recorded daily. The lengths of shoot and root of rice seedlings were measured seven days after sowing. The experiments were conducted at room temperature.

Analytical

Ammoniacal-N was determined by Richardson's modification of Olsen's method, as described by Piper (1950). Nitrate-N and initial total-N were determined following Piper's procedure. Total-N after the onset of the experiments was calculated by adding NO_3-N to Piper's total-N values for the Brahmaputra and Gangetic alluviums; and for the Coastal saline and Madhupur red soils total-N was determined following Kjeldahl's method modified by Jackson (1962). This determination also included NO_3-N. As the amount of NO_3-N accumulated in the Brahmaputra and Gangetic alluviums was little during this short period of observation (seven days), the Jackson method was preferred for the latter soils. Total-N of organic materials was determined by the A.O.A.C. (1960) method. Mechanical composition of the soil was analysed by pipette sampling, as described by Piper, and organic C by the wet oxidation method of Walkley and Black (1934). The pH was determined with a glass electrode. Soluble K in the soil was determined by Dyer's 1% citric acid extraction method, followed by precipitation with cobaltinitrite and oxidation with $KMnO_4$ as outlined by Piper (*ibid.*). Available P in the soil was determined by Truog's (1930) 0.002 N H_2SO_4 method, followed by colorimetric estimation of the colour of the phospho-molybdate complex. Total P, total K and total Ca were determined from a HCl extract of a sodium carbonate fusate. Total P was determined colorimetrically by developing the blue colour of the phospho-molybdate complex, total K volumetrically (Piper, *ibid.*), and total Ca by double oxalate precipitation and oxidizing the oxalate by

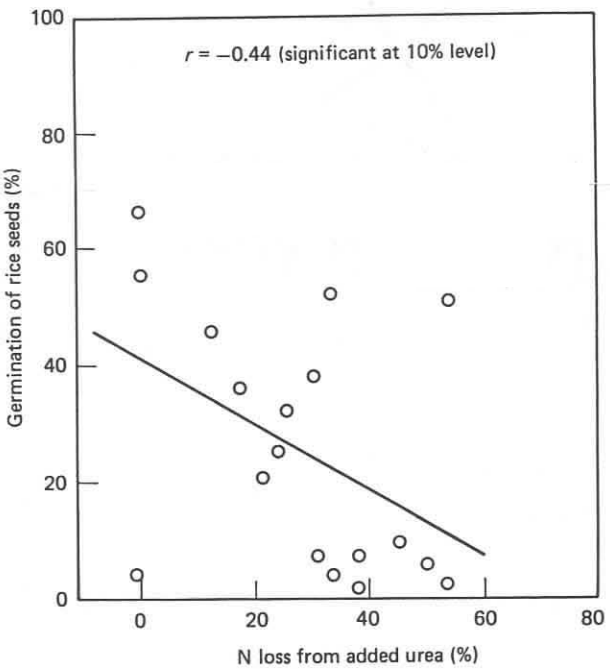

Figure 1 Relationship between percentage germination of rice seeds counted on fourth day after sowing, and percentage N-loss from added urea after three days

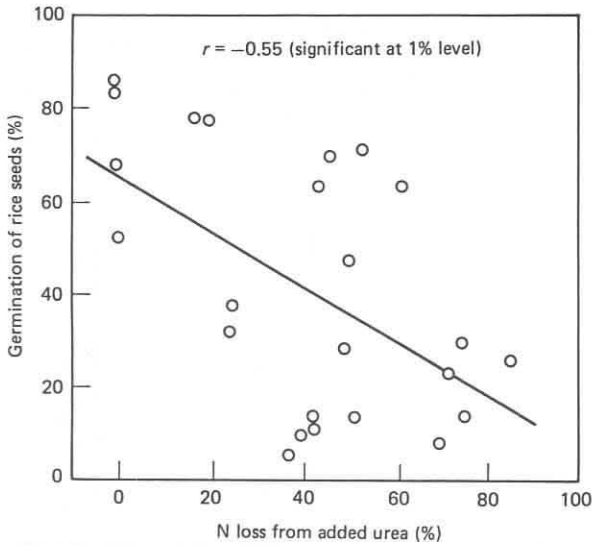

Figure 2 Relationship between percentage germination of rice seeds counted on seventh day after sowing, and percentage N-loss from added urea after seven days

$KMnO_4$ (Piper, *ibid.*). Total P of bonemeal was determined colorimetrically by the A.O.A.C. (*ibid.*) method.

Results and discussion

The loss of N from volatilization of added urea was calculated by deducting the total amount of N present in the soil after a specified time period from the sum total of initial N (Soil N + added N). N loss varied between 13–36%, and 17–39% of added N after three and seven days, respectively, when urea was applied alone; and between 24–62%, and

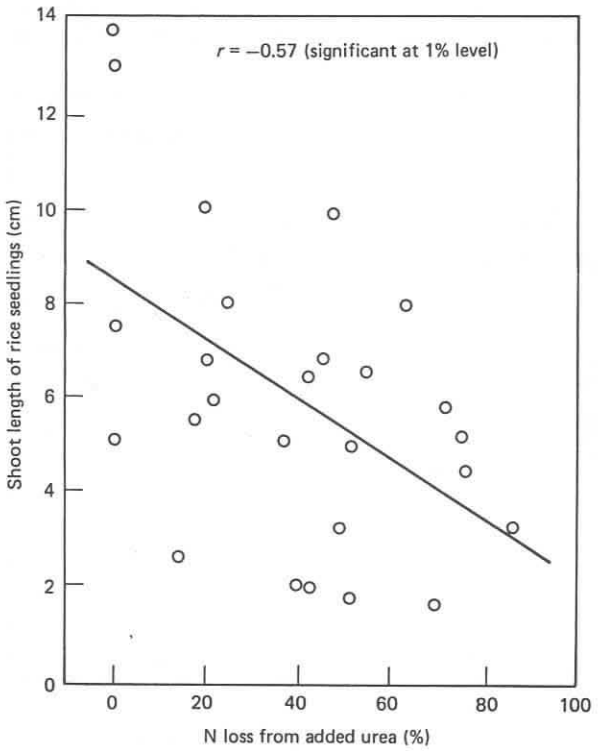

Figure 3 Relationship between shoot length of rice seedlings recorded on seventh day after sowing, and percentage N-loss from added urea after seven days

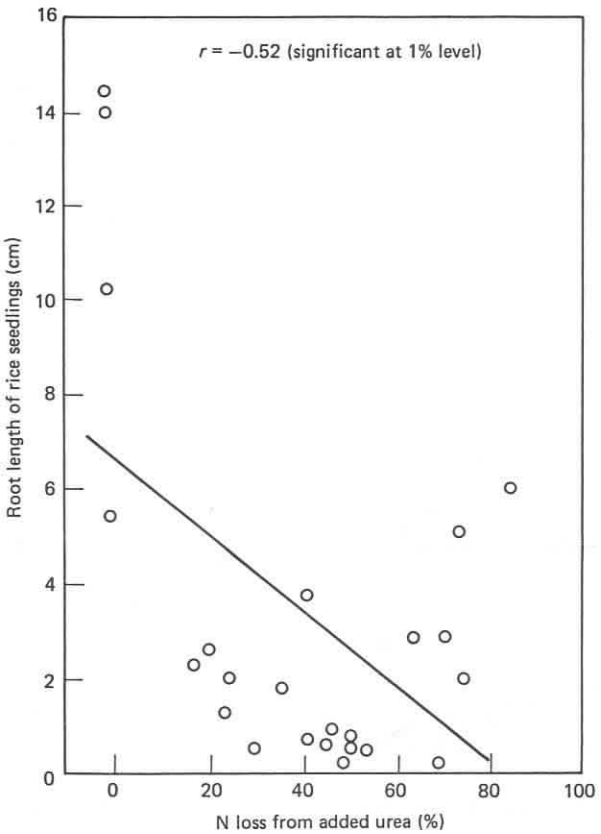

Figure 4 Relationship between root length of rice seedlings recorded on seventh day after sowing, and percentage N-loss from added urea after seven days

44–75% of added urea-N after three and seven days, respectively, in the presence of organic materials, except bonemeal which showed little effect on N loss, in different soils. The germination of rice and jute seeds and the growth of rice seedlings were severely inhibited by urea alone, and urea +

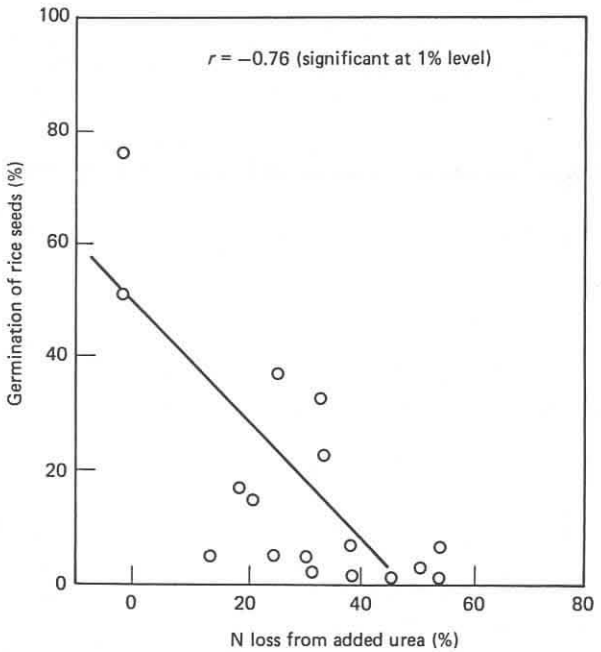

Figure 5 Relationship between percentage germination of jute seeds counted on fourth day after sowing, and percentage N-loss from added urea after three days

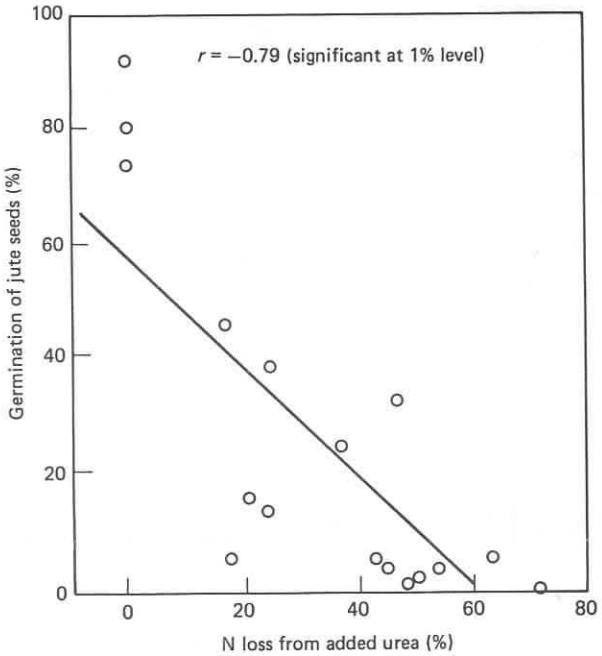

Figure 6 Relationship between percentage germination of jute seeds counted on sixth day after sowing, and percentage N-loss from added urea after seven days

organic materials in all cases. The inhibitory effect was much more pronounced with jute compared with rice. The damaging effect of ammonia was so severe that almost all germinated jute seedlings were dead on day 6 after sowing in the urea and organic materials treated soils; as a result shoot and root growth could not be recorded.

Results on the relationships between urea-N loss and germination and seedling growth of crops are presented in Figures 1–6. Observations on percentage germination plotted in the vertical axes in Figures 1–2 and 5–6 were cumulative counts of germination per 100 seeds. Data on the percentage urea-N loss, shown in the horizontal axes were obtained from the series marked for observing the volatilization losses of N. For rice (Figures 1–4) there were 24 treatments (six treatments × four soils); and for jute (Figures 5–6) there were 18 treatments (six treatments × three soils) because of the exclusion of Coastal saline soil where no germination of jute seeds was observed. Figure 1, however, shows 18 points instead of 24, because no germination was observed in the Coastal saline soil three days after sowing. Germination of rice seeds recorded on days 4 and 7 (Figures 1 and 2) and seedling growth of rice recorded on day 7 (Figures 3 and 4) were negatively correlated with N-loss from added urea. Similarly, germination of jute seeds recorded on days 4 and 7 (Figures 5–6) after sowing were negatively correlated with N-loss from added urea.

The gaseous losses of N from added urea might have occurred mostly in the form of ammonia due to volatilization (Sreenivasan and Subrahmanyan, 1935; Willis and Sturgis, 1945; Steenbjerg, 1947; Martin and Chapman, 1951; Khan and Rashid, 1971; Rashid, 1977). The negative correlations between N-loss percentage from added urea and seed emergence and seedling growth of crops (Figures 1–6) seem, therefore, to indicate that the ammonia gas came in contact with the seeds and seedlings and damaged them during the course of its escape to the atmosphere. The present work indicates that one should be careful while applying urea during the germination of seeds and the initial growth of seedlings.

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